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VEHICLE IMAGING AND VERIFICATION

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(57) Claim

1. A method of imaging and verifying vehicle data, including the steps of:

(a) capturing a digital image of a vehicle;

(b) capturing a digital image corresponding with the vehicle's licence plate;

(c) conducting optical character recognition on the licence plate to determine the registration number;

(d) communicating with a vehicles database to receive information concerning the vehicle matching the registration number; and

(e) displaying the image and information for operator verification.

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ORIGINAL
COMPLETE SPECIFICATION
STANDARD PATENT

Invention Title: VEHICLE IMAGING AND VERIFICATION

Applicant: REDFLEX TRAFFIC SYSTEMS PTY LTD

The following statement is a full description of this invention, including the best method of performing it known to me:

Vehicle Imaging and Verification

This invention relates to a method of imaging and verifying vehicle data. It relates particularly, but not exclusively, to a method which permits an operator to perform real-time verification of imaged vehicles.

There are various different applications for vehicle imaging. These include: Speed (photoradar) and red Light Camera Operations, Traffic Violation Detection and Processing, Route Interval Timing, Access Control, Intersection Control, Long Term Surveillance, Car Parks, Incident detection, and Vehicle Tracking.

The present invention has application to all of these areas, although the following discussion will concentrate particularly on speed and red light cameras.

Speed and red light cameras in use today are predominantly celluloid film based. Images of infringing vehicles are captured on 35mm film and subsequently viewed with film viewers or projectors, or alternatively converted into digital form by using any one of a range of digital film scanners. An operator identifies the vehicle registration number from the photograph, perhaps using an enlargement of a portion of the image, and a database of vehicle registration details is then interrogated to locate other relevant vehicle information, such as make, model and colour. If the information matches the image, an infringement notice is issued. In cases where the images are converted into digital form, the registration number may be identified automatically by an optical character recognition process, such as template matching or neural networks.

Major costs associated with traffic camera operations includethe processing of film together with the internal costs of managing the supply, handling and archiving of the medium. In jurisdictions where photographs are scanned and processed digitally, the photographic processes are a hindrance to efficient operations, as much of the equipment used is for the sole purpose of translating the film into digital form. This is expensive in terms of capital investment, labour and maintenance.

Film processes also introduce delays in the issue of infringement notices. In one typical jurisdiction, it currently takes about 5 days to receive the film, process it and issue the infringement notice. Delays of this length or greater are undesirable because it is believed that the effectiveness of a traffic infringement

notice system as a deterrent is inversely proportional to the length of time between the infringing act and the receipt of the infringement notice.

Another major limitation of film is associated with the digital scanning process. The conversion of film into digital images introduces degradation in image quality which often affects the legibility of the offending vehicle's licence plate. The consequence is a reduction in the prosecution rate which means productivity deficiencies, lost revenue, but more importantly, a reduction in the effectiveness of the overall program.

There is a need for a more efficient way of capturing images and verifying vehicle data.

The present application is related to applications filed at the same time by the same applicant entitled "Imaging Apparatus" (claiming priority from Australian Provisional Application PO5257 filed 24 February 1997) and "Digital Image Processing" (claiming priority from Australian Provisional Application PO5258 filed 24 February 1997). The contents of those applications are hereby incorporated herein by reference.

Summary of the Invention

According to the present invention, there is provided a method of imaging and verifying vehicle data, including the steps of:

(a) capturing a digital image of a vehicle;

(b) capturing a digital image corresponding with the vehicle's licence plate;

(c) conducting optical character recognition on the licence plate to determine the registration number;

(d) communicating with a vehicles database to receive information concerning the vehicle matching the registration number; and

(e) displaying the image and information for operator verification.

In one preferred arrangement, steps (a), (b) and (c) be performed at the location of the digital imaging apparatus. This can result in a significant reduction in the amount of digital information which must be retained, as a low resolution image of the vehicle together with a high resolution image of the licence plate

may be sufficient, depending upon the regulatory requirements of the particular jurisdiction. Moreover, these are steps which take significant time in present processing operations, and efficiency will be improved if they can be completed before operator intervention is required.

In this arrangement, all of steps (a) to (c) and (e) may be performed at the location of the digital imaging apparatus. This arrangement is particularly suitable for situations where the imaging apparatus is located in a car with an operator. All of steps (a) to (d) can be performed automatically before the results are displayed to the in-car operator, who verifies that the licence number identified by the optical character recognition does indeed match the licence plate on the image, and also that the vehicle details from the vehicle database match the vehicle image. In some jurisdictions, an infringement notice can then be issued immediately. In other jurisdictions, independent verification by another operator is required before the notice can be sent. In either event, considerable processing time is saved, and the camera operator's time is used more efficiently.

In another preferred arrangement, steps (c) to (e), and possibly also step (b) are performed at one or more sites remote from the camera site at which step (a) is performed. This arrangement is particularly suitable for fixed deployments such as red-light cameras and for jurisdictions in which it is not necessary to have an operator on-site when images are taken. This arrangement allows from a central control room from which operators supervise the operation of multiple cameras remotely by interfacing with cameras by means of serial communications such as telephone, ISDN, fibre optics, Internet, etc. The bulk of the processing may still be performed on site, with the operator verifying the outputs and issuing manual commands.

The step of capturing a digital image of the vehicle may be done in any suitable manner. Most digital imaging is done using charge coupled devices (CCDs), and it is preferred that CCDs be used. Imaging may be done by means of commonly available CCDs. More preferably, higher resolution imaging is achieved using a high-resolution single CCD; alternatively, the imaging may involve segmenting the image into an array of sub-images, each of which is detected by one of an array of CCD detectors, and the sub-images may be

recombined by digital processing techniques, as described in the afore-mentioned co-pending patent application entitled "Imaging Apparatus".

Ordinary currently available video cameras use CCDs which deliver an analog signal with a limited line resolution, typically around 600 lines or less. This signal can be digitised and produces an image resolution which is high enough to obtain an overall image of a vehicle, but not high enough for the vehicle's licence plate to be legible in the image. It is sufficient for step (a) above to have a low resolution image of the vehicle, but step (b) above requires a high resolution image of at least the licence plate.

The step of capturing a digital image corresponding with the vehicle's licence plate may be done in any suitable manner. This may involve taking two digital photographs at the same time with two cameras, one a wide-angle photograph to capture the vehicle and surrounding scene, and one with a zoom lens to capture the vehicle's licence plate. This method relies on assumptions concerning the standard position of the licence plate in a photograph in order to establish the alignment of the zoom camera, and it is unreliable if the infringing vehicle is of non-standard size or shape or is moving in an unexpected direction or non-centrally in the traffic lane.

In some jurisdictions, particularly those in which vehicles are required to carry licence plates on the back but not on the front, two images are in any event necessary, one from the front of the vehicle to identify the vehicle and possibly also the driver, and one from the back to identify the licence plate.

An alternative to taking two photographs simultaneously is to take one wide-angle photograph as soon as the infringement is detected, and then to use a high-speed zoom to capture an image of the vehicle's licence plate region. However, this approach requires assumptions to be made about the predicted standard position of the licence plate at a predetermined time after the first photograph has been taken, and it is therefore less reliable than the simultaneous photographs technique.

A further problem with the use of standard video cameras in capturing images is the low dynamic range available in digitised images. Bright spots on a dark image, such as a retro-reflective licence plate in an image captured at night,

tend to "burn out", so that the licence plate is not legible. Dark spots on a bright image, such as the driver in a vehicle photographed on a sunny day, may be so dark that the driver is not recognisable. Moreover, the low dynamic range of typical video cameras usually makes it necessary to provide a slow shutter speed for taking dark images such as night-time photographs, and this results in blurring of the licence plate details due to movement of the vehicle.

It is therefore preferred that the digital image corresponding with the vehicle's licence plate be a high resolution image with high dynamic range. It is further preferred that the licence plate image be part of a larger high-resolution image which covers a region large enough to capture the licence plate even if the licence plate appears in a region different from that expected by standard assumptions. It is especially preferred that the digital image of the vehicle captured in step (a) above be a high-resolution image, and the licence plate digital image of step (b) be obtained by extracting the licence plate region from the high-resolution vehicle image.

Extraction may be based on a common region of all images. For example, the apparatus could be set up in such a way that a vehicle licence plate appears in the exact centre of each image. This can be accomplished more easily if secondary vehicle position information is provided. For red light enforcement this information may be provided by induction loops placed under the road surface in each lane. When a vehicle infringes a red light, it passes over an inductive loop that has been placed on or about the stop line. The inductive loop senses a magnetic disturbance and reports this event to the camera's control unit. When the vehicle crosses a second loop approximately 3 metres from the first (ideally located in the cross walk area) the camera control unit calculates the vehicle speed and triggers the camera if the vehicle exceeds a preset threshold. Since each lane is equipped with its own set of loops the camera control unit is able to determine the relative vehicle position.

For speed detection, a radar system may be coupled with a range finding device such as a laser which profiles the vehicle as it enters the radar beam. The radar can provide the vehicle speed, while the laser provides the relative distance from which lane information can be gathered. Since the laser is actually profiling

the vehicle, it has the ability to determine the exact position of either the front or the back of the vehicle, delaying the camera trigger until the optimum vehicle position is achieved. One such device is AWA's VSL (Vehicle Speed Laser-radar).

Alternatively, extraction may be based on a pattern in the image being recognised as a licence plate. Almost all licence plates are retro-reflective, and licence plates can often be recognised as bright spots on the images, particularly when the images are taken under dark lighting conditions with the assistance of a flash unit which is in line with the camera. A licence plate is usually distinguishable from other bright spots such as vehicle headlights because of its shape. Standard computer pattern recognition techniques can be used, and the operator can be given an opportunity to specify the licence plate area if the computer fails to recognise the correct area. Further preferred features of digital image processing steps are described in the afore-mentioned co-pending patent application entitled "Digital Image Processing".

The step of conducting optical character recognition may be done in any suitable manner. Optical character recognition may be done according to standard OCR techniques. The operator may be given an opportunity to specify the correct registration number if the computer cannot complete optical character recognition or if the recognition is incorrect.

The step of communicating with a vehicles database may be done in any suitable manner. Communication may be by means of radio, telephone lines, fibre optics lines, dedicated data lines, or any other suitable communication medium. The database may even be stored on the operator's computer if security and privacy laws for the particular jurisdiction permit.

The step of displaying the image and information for operator verification may be accomplished in any suitable manner. It is preferred that the information displayed include the image of the vehicle, a close-up view of the area recognised by the computer as the licence plate, the registration number identified by the OCR step, and vehicle make, model and colour information provided by the database. Other information could also be displayed, depending upon the particular regulatory requirements of the jurisdiction.

The method of the invention may further include the step of storing the digital image and other information in a computer storage medium for further reference and for evidentiary and archival purposes. It is preferred that the image be compressed before storage using a compression technique which results in little or no loss of image information. It is also preferred that the storage medium incorporate means for securing against tampering or unauthorised access.

The method of the invention may further include the step of capturing and storing a video buffer being a video recording of the vehicle and surrounding scene for a few seconds before and/or after the event which gives rise to the taking of the photograph. Such a video buffer can be helpful in proving or disproving a traffic violation.

Apparatus for accomplishing the method of the invention may include a digital camera, digital image processing apparatus, optical character recognition apparatus, database accessing apparatus, and image and information display apparatus.

As an optional enhancement to such apparatus, there may be provided a high frequency sound sensor to detect such incidents as screeching tyres or breaking glass and automatically activate the digital camera to give supervising operators early warning of a traffic incident.

The invention will now be described in more detail by reference to the drawings. It is to be understood that the particularity of the drawings does not supersede the generality of the preceding description of the invention.

Description of the Drawings

Figure 1 is a flow diagram of an embodiment of the method of the present invention.

Figures 2 and 3 are schematic illustrations of vehicles on a four-lane road, demonstrating the maximum and minimum distances of vehicle from imaging apparatus.

Figure 4 illustrates the concept of dividing an image into sub-images in accordance with an aspect of the invention.

Figure 5 illustrates the same concept, with the image segmented into a 5 x

5 array of sub-images.

Figure 6 is a simplified schematic diagram of image-segmentation or beam-splitting apparatus.

Figure 7 is a diagram of a more detailed preferred beam-splitting arrangement using lenses.

Figure 8 is a speed camera photograph illustrating an over-exposed licence plate.

Figure 9 is a histogram showing intensity distributions of pixels in a speed camera photograph.

Figure 10 is a graph showing a mapping of an 8-bit image to a 4-bit image in a way which enhances licence plate legibility.

Figure 11 is the image of Figure 8 after processing according to the mapping technique of Figure 10.

Figure 12 is a block diagram of a data processing arrangement according to one embodiment of the invention.

Referring firstly to Figure 1, there is shown a method of imaging and verifying vehicle data according to the invention, involving several steps. The first step consists of capturing a digital image of a vehicle. As shown in more detail in Figures 4 to 7, and described hereafter, one preferred method for accomplishing this step is by first splitting the image into multiple sub-images, detecting the sub-images using an array of CCDs, and then recombining the image data digitally.

The next step shown in Figure 1 involves capturing a digital image corresponding with the vehicle's licence plate. In a preferred arrangement this involves extracting the relevant region from the vehicle digital image. This step is explained in more detail hereafter with respect to Figures 8 to 11. The next step comprises conducting optical character recognition on the licence plate to determine the registration number. This is done according to known OCR techniques. The next step involves communicating with a vehicles database to receive information concerning the vehicle matching the registration number. This step is also done according to standard database interrogation and

communications techniques; and the final step consists of displaying the image and information for operator verification. The display may be on any suitable computer display device, such as a cathode ray tube, liquid crystal display, or gas plasma display.

According to standard design specifications for a traffic camera, the camera must provide an optical performance such that a vehicle travelling away from the camera on a four lane road is still in focus. The licence plate at the rear of the vehicle must be machine readable. This position is illustrated in Figure 2, which shows a stationary vehicle 1 which has radar and camera apparatus, and which is parked immediately adjacent the edge 2 of a four-lane road 3. A moving vehicle 4 is travelling away from the camera in the fourth or furthest lane 5 from the camera. The maximum field of view, that is the focal depth, is determined by Figure 2 together with the equation:-

$$\text{Camera FoV}_{max} = \frac{\text{Total Road Width + Radar Camera Offset}}{\sin(\text{Radar Angle - (Radar FoV angle / 2)})}$$
$$= \frac{(3.5 + 3.5 + 3.5 + 3.5 + 1.75)}{\sin(20 - (10 / 2))}$$
$$= 60.68\text{m}$$

Figure 3, which illustrates the method for determining the minimum field of view, shows a stationary vehicle 6 which has radar and camera apparatus and which is parked immediately adjacent the edge 7 of a road 8. A moving vehicle 9 is travelling along road 8 towards the camera. The minimum camera field of view, that is the focal depth, can be determined as illustrated in Figure 3 together with the equation:-

$$\text{Camera FoV}_{min} = \frac{\text{Minimum Road Width + Radar Camera Offset}}{\sin(\text{Radar Angle + (Radar FoV angle / 2)})}$$
$$= \frac{(3.5 + 1.75)}{\sin(20 + (10 / 2))}$$
$$= 10.06\text{m}$$

From these constraints it is possible to calculate the minimum and maximum Licence Plate sizes, and the digital resolution necessary to provide adequate image quality.

Capturing a Digital Image

The Charge Coupled Device or CCD is a image acquisition device capable of converting light energy emitted or reflected from an object into a electrical charge which is directly proportional to the entering light's intensity. The CCD is in

theory capable of providing excellent dynamic resolution but unfortunately due the manufacturing complexity and current world demand, can only deliver limited spatial density or resolution.

Core utilisation of CCD technology is in the home video market which demands only a low resolution of the order 752x582 (standard Hi 8 Sony palm camera) pixels. Although special order CCDs can be manufactured to deliver higher resolution, they prove to be economically prohibitive because of their special-order nature and operating requirements.

However, with the utilisation of optical science, the objective image can be broken into smaller components as illustrated in Figures 4 and 5 and distributed to several CCDs arranged in a special array in order to provide the necessary resolution. As each sub-image is distributed to each CCD, a central processor can digitally build the original image, much like putting a jig-saw together. Using special image processing algorithms, joins can be smoothed removing any evidence of image disruption. Figure 4 shows a complete image 10, broken up into nine separate sub-images 11.

An advanced optical system is used to distribute the primary image into 25 separate images with minimum distortion and loss to each individual CCD. It has been found that a 5 x 5 array produces a suitable final resolution. In addition to the 25 CCDs, a low resolution image of the entire primary image will be captured by utilising another CCD of the same type. The 26th CCD is positioned such that it does not interfere with any of the 25 optical paths. Figure 5 shows an arrangement in which an image is broken up into a 5 x 5 array of sub-images 12, with a low-resolution complete image 13 being captured at the same time.

Figure 6 is a simplified diagram of the image separation or beam-splitting step. There are various different beam-splitting techniques which can be used, including partial mirrors, lenses and a parallel array of coherent fibre optic bundles. Light which forms the image to be captured passes through objective lens 14. The light then passes through beam splitter 15 and is split into separate sub-images. These sub-images are then detected by CCD elements 16, one CCD detecting each sub-image.

Figure 7 is a more detailed diagram of a preferred lens arrangement. Light passes into the imaging apparatus through the objective lens 17, which has eight elements. It then passes through a beam splitter or partially silvered mirror 18 which allows approximately 96% of the incident light to pass and reflects approximately 4% of the incident light through lenses 19 to form a low resolution image on CCD 20. The majority of the light then passes through field lens 21 and three-element collimator 22 and finally through an array of focussing lenses 23 before forming separate sub-images on an array of CCDs 24.

To eliminate any evidence of sub-image distribution over the CCD array, a small percentage of adjacent or neighbouring CCD sub-images are overlaid onto each CCD. This allows for seamless reconstruction and image processing techniques to smooth any capture difference resulting from chromatic and intensity loss.

Experimentation has revealed that suitable imaging results can be obtained using a 5 x 5 array of Sony CCDs of type ICX075, which have a resolution of 784 x 584 pixels, a pixel size of 8 micron by 8 micron, and a dynamic range of 65dB. More recent experimentation with the soon-to-be-released high resolution Sony CCDs of type ICX205, which have a resolution of 1434 x 1050 pixels, of which 1392 x 1040 pixels are useable, a pixel size of 4 micron by 4 micron, and a dynamic range of 70dB has revealed that satisfactory results can be achieved using a 2 x 2 array of such CCDs. This is now the preferred imaging apparatus, because it is much easier to construct a 2 x 2 array than a 5 x 5 array.

The preferred imaging apparatus is described in more detail in theaforementioned co-pending patent application entitled "Imaging Apparatus".

Processing the Digital Image Data

There are several aspects to processing the digital image data. The first aspect involves matching data from adjacent CCDs to recreate the total image. This is accomplished according to standard pattern-recognition and matching techniques. Other aspects include selection of an area of particular interest for high-resolution viewing (the licence plate region), image data modification (particularly to compensate for over-exposure caused by the action of a flash unit on retro-reflective licence plates), and image data compression.

When images are taken in dark conditions using a flash unit which is on the same axis as the camera, the brightest area of a speed and red-light violation image is on the retro-reflective licence plate area, the car head lamps or other white areas. This means that these areas reflect most light energy, causing higher intensity light to enter the camera. This can result in over exposure when developing the image, making the licence plate details unreadable. Figure 8 shows a typical speed camera photograph, with a dark background area 25 and the licence plate area 26 over-exposed.

Figure 9 shows a typical histogram of the intensities of individual pixels in a speed violation image. Because of its almost universally retro-reflective nature, the Licence Plate is almost always located at the high 10-20% of the intensity graph 27 for images taken in dark conditions using a flash unit. In order to make the Licence Plate readable, a preferred feature of the present invention provides for the intensity values of the pixels in the licence plate area to be decreased.

Because the image information relating to the background scene and the vehicle (other than the licence plate) is of less relative importance in a vehicle image, such information can be compressed to a significant extent. Compression can occur at the same time as the Licence Plate is made readable. By way of example, the image may include 8-bit intensity information (255 levels of intensity). This can be converted to a 4-bit image (16 levels of brightness), in which 6 levels (the high 10-20% of intensity levels) are assigned to the Licence Plate and 10 levels (the low 80-90% of intensity levels) are assigned to the rest of the image. An algorithm for accomplishing this is described below:

Compute the highest intensity (Ymax) of the image. The lowest intensity is assumed to be zero.

Calculate 10-20% high intensity range from the Ymax.

Compute the magnitude of each division for Scene image (10 levels) - Scene Div and License Plate image (6 levels) - LP Div.

Convert each pixel of the image to intensity Y.

For each pixel Y,

if the intensity is in the "Scene" range, divide the intensity with the Scene Div .

if the intensity is in the "Licence Plate" range, divide the intensity with the LP Div.

For the purpose of displaying the 4-bit image with a graphics program, the resulting 4-bit image is to convert back to an equivalent 8-bit image by multiplying the conversion factor (255/16).

For example: If Ymax = 240.

20% intensity of the high end is 240 * .8 = 192

If a calculated Y intensity is 180 (in low intensity range) , then the equivalent level is = 180 / Scene Div.

If a calculated Y intensity is 230 (in high intensity range) , then the equivalent level is = ((240 - 230) / LP Div) + 10.

The above example is illustrated in Figure 10, which is a graph mapping original 8-bit image intensity levels (255 levels) to compressed 4-bit (16 levels) image intensity levels. Figure 11 is a photograph showing the image of Figure 8 after the image compression process. Some detail has been lost from the background scene 25, but the blown-up view of the licence plate region 26 shows the licence plate as clearly legible.

The above example relates to an application in which it is important to reduce the intensity of pixels in a region to ensure clarity of that region. Similar techniques are also applicable to enhancing the intensity of pixels in a region. For example, in some jurisdictions it is necessary to be able to identify the driver before a traffic infringement notice can be issued. In most cases, the driver's features will be darker than most of the image. By selectively increasing the intensity of pixels in the region of the image where the driver's face appears, the driver may be more readily recognised.

It is of course not necessary in all cases for image intensity manipulation to occur. Image compression is, however, important because of the enormous sizes of files generated by digital images which have sufficient resolution to enable accurate recognition of licence plate details. In order for the invention to be practicable, a reasonable number of images must be able to fit onto a computer storage device (such as a removable hard disk), and image data must be capable of being transferred through computer processing stages at a reasonable rate. Compression may occur before or after the image has been viewed by an

operator. It is preferred that the operator view the image after compression so that the image quality has been ascertained.

In compressing an image file, it is important to store a high-resolution image of the licence plate area, but the rest of the image can usually be stored at lower resolution (depending upon regulatory requirements for the particular jurisdiction). Thus there is scope for reducing image size both by reducing pixel intensity information (the number of different intensity levels, as discussed above) and by reducing the number of pixels per unit area (other than in the licence plate area). As mentioned previously, the licence plate area is preferably identified by intelligent recognition techniques. Where, as in the presently preferred forms of the invention, the high resolution image is generated from a 2 x 2 array or a 5 x 5 array of sub-images, it is preferred that an additional CCD capture a lower-resolution overall image. This image can provide the basis of the lower-resolution background scene image which is stored along with the higher-resolution licence plate image which is extracted from the higher resolution overall image.

It is preferred that the data processing steps include a form of data encryption to preserve data security and prevent unauthorised access. The compression techniques selected may encompass an acceptable encryption algorithm; alternatively, encryption may be applied after compression. It is possible to apply encryption before compression, but this may adversely affect compression efficiency.

A block diagram for the data section of the CCD system according to one embodiment of the invention is shown in Fig 12. In this arrangement, sub-images are detected by the array of CCDs 28. Data from each CCD 28 is passed to a corresponding analog front-end processor 29, and data from a group of processors 29 is combined and passed into analog multiplexers 30, and from there via analog to digital converters 31 to data compressor 32, and on to a computer for further processing via PCI bus interface 33.

Other techniques for image processing are discussed in the afore-mentioned co-pending patent application entitled "Digital Image Processing".

It is to be understood that various alterations, additions and/or modifications may be made to the parts previously described without departing from the ambit of the invention.

The claims defining the invention are as follows:

1. A method of imaging and verifying vehicle data, including the steps of:

(a) capturing a digital image of a vehicle;

(b) capturing a digital image corresponding with the vehicle's licence plate;

(c) conducting optical character recognition on the licence plate to determine the registration number;

(d) communicating with a vehicles database to receive information concerning the vehicle matching the registration number; and

(e) displaying the image and information for operator verification.

2. A method according to claim 1 wherein the step of capturing a digital image corresponding with the vehicle's licence plate involves extracting a region of the digital image captured in the step of capturing a digital image of a vehicle.

3. A method according to claim 1 or claim 2 wherein steps (a), (b) and (c) are performed at the same location.

4. A method according to claim 3 wherein step (e) is also performed at the same location.

5. A method according to claim 1 or claim 2 wherein step (a) is performed at one location and steps (c) to (e) are performed at a different location.

6. A method according to claim 1 or claim 2 wherein the step of capturing a digital image of a vehicle involves capturing multiple sub-images and subsequently combining them into a high resolution image using digital processing techniques.

7. A method according to claim 1 or claim 2 wherein the step of capturing a digital image corresponding with the vehicle's licence plate involves digitally adjusting the intensities of pixels in the image to improve legibility.

8. A method according to claim 1 or claim 2 further including the step of storing the digital image and other information in a computer storage medium for further reference or for evidentiary or archival purposes.

9. A method according to claim 8 further including the steps of capturing and storing a video image buffer being a video recording of the vehicle for a few seconds before and/or after the performance of step (a).

10. Apparatus for accomplishing the method of claim 1 or claim 2 including a digital camera, digital image processing apparatus, optical character recognition apparatus, database accessing apparatus, and image and information display apparatus.

11. Apparatus according to claim 10 further including a high frequency sound sensor to detect such incidents as screeching tyres or breaking glass and automatically activate the digital camera to give supervising operators early warning of a traffic incident.

DATED: 24 February, 1998

Phillips Ormonde & Fitzpatrick
Patent Attorneys for:
REDFLEX TRAFFIC SYSTEMS PTY LTD.

David B Fitzpatrick

ABSTRACT

A method of imaging and verifying vehicle data, includes the steps of capturing a digital image of a vehicle; capturing a digital image corresponding with the vehicle's licence plate; conducting optical character recognition on the licence plate to determine the registration number; communicating with a vehicles database to receive information concerning the vehicle matching the registration number; and displaying the image and information for operator verification.

Apparatus for accomplishing the method includes a digital camera, digital image processing apparatus, optical character recognition apparatus, database accessing apparatus, and image and information display apparatus.

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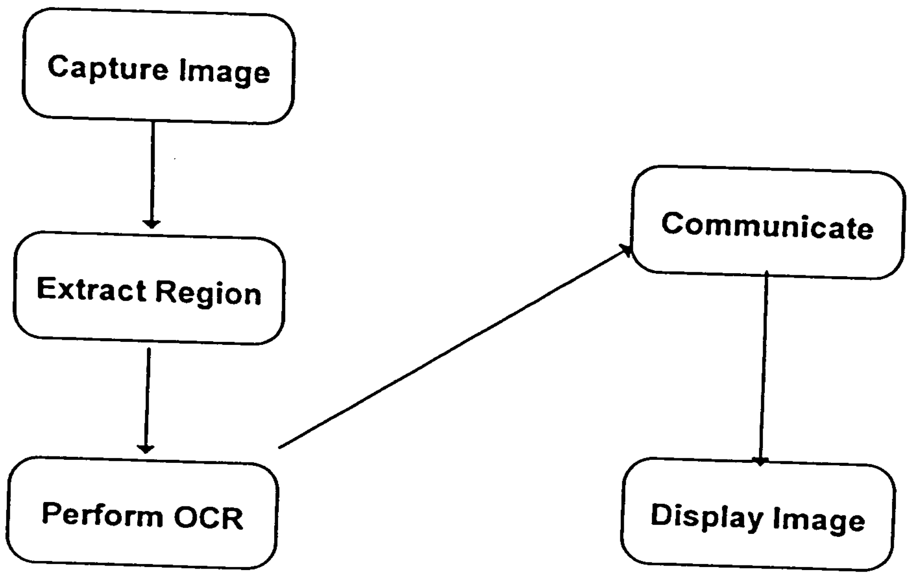


FIG 1

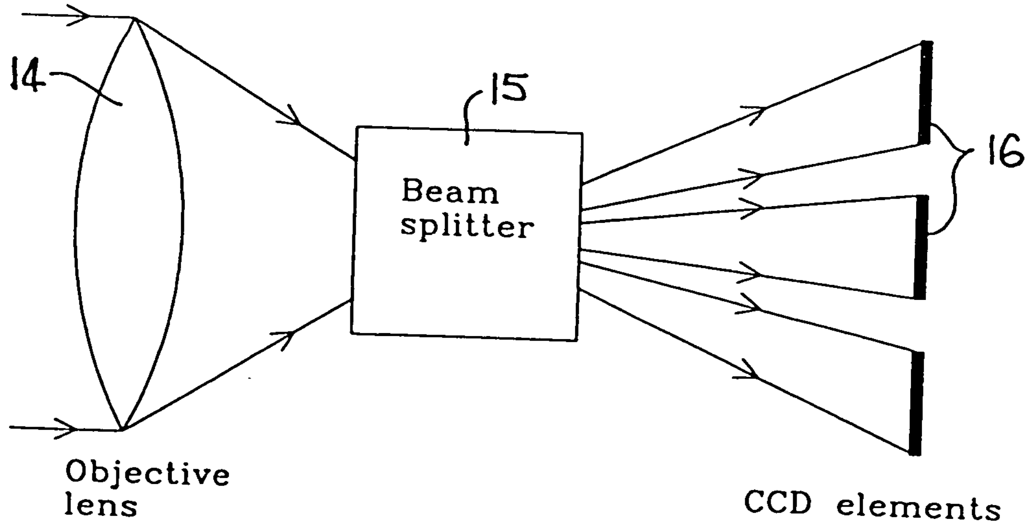


FIG 6

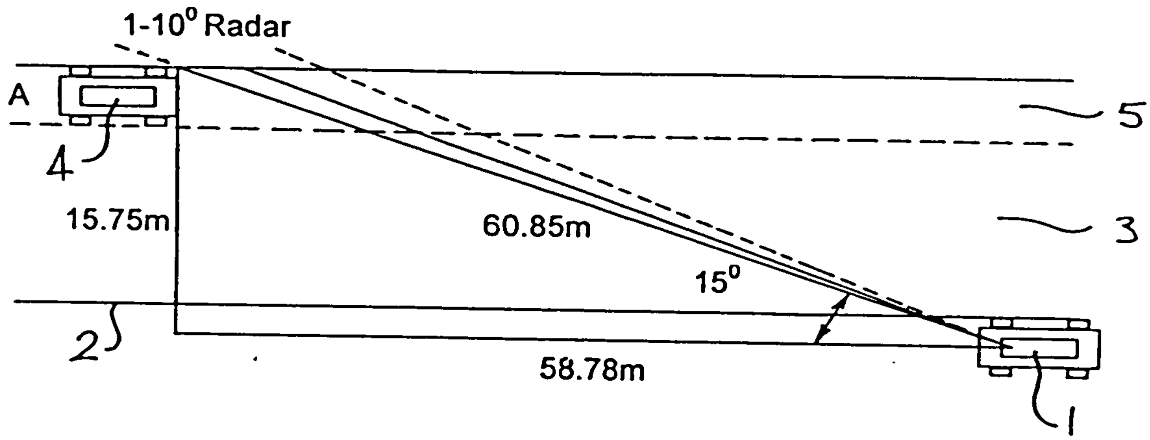

1-10° Radar
A
4
5
3
15.75m
60.85m
15°
2
58.78m
1

FIG 2

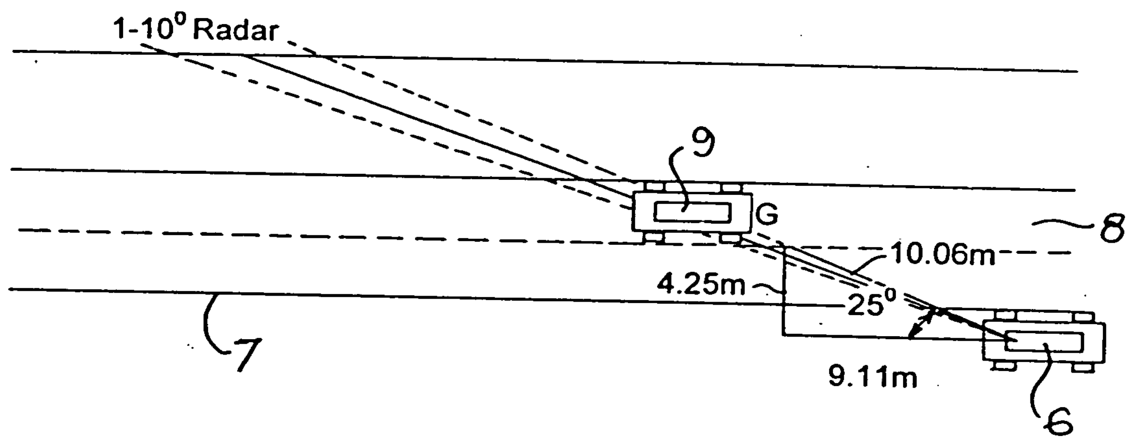
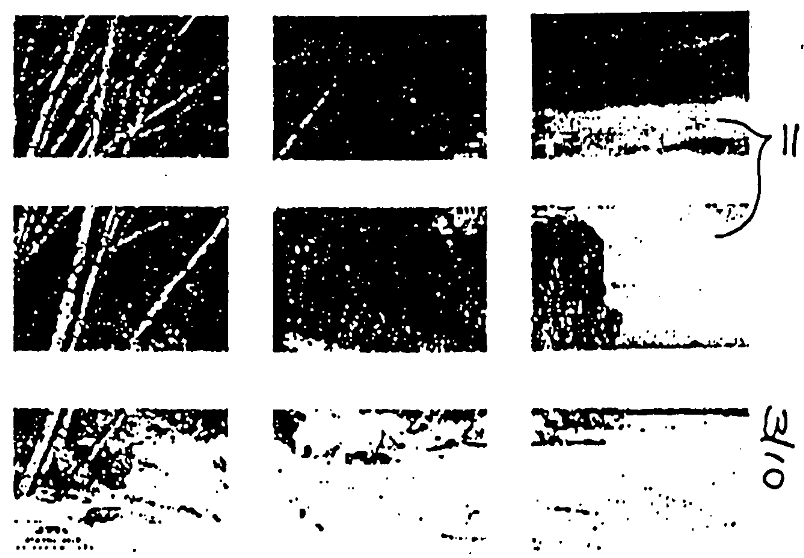

1-10° Radar
9
G
8
10.06m
4.25m
25°
7
9.11m
6

FIG 3

Complete Image

FIG 4a



Separate images seen by each CCD

FIG 4b

FIG 5a

FIG 5b

24 02 98 56300

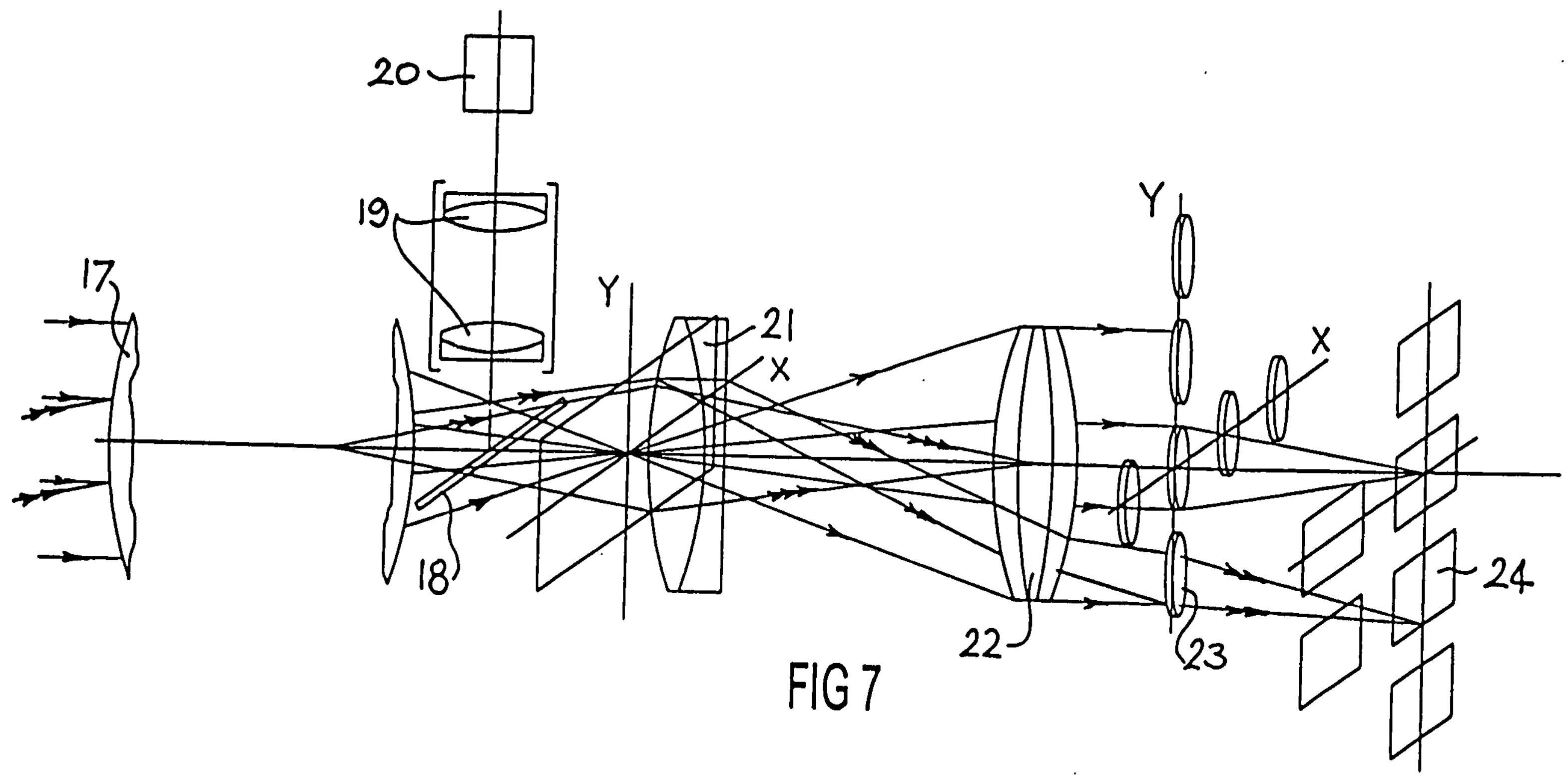


FIG 7

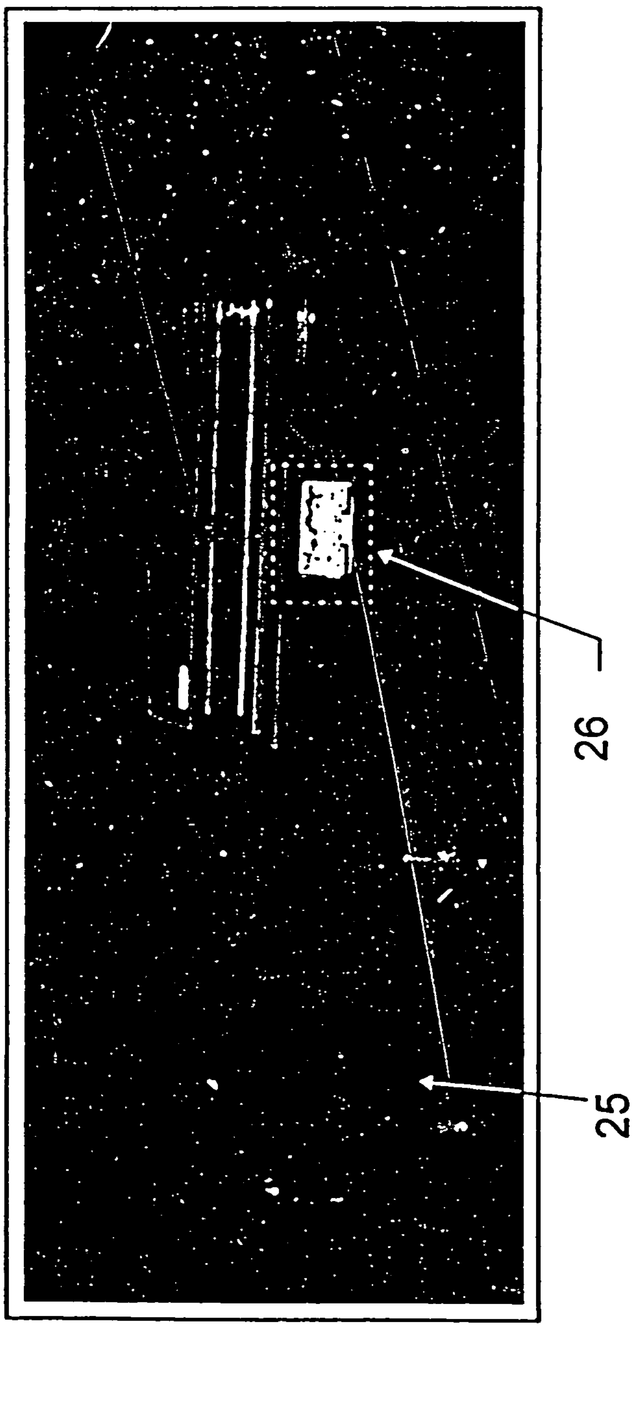
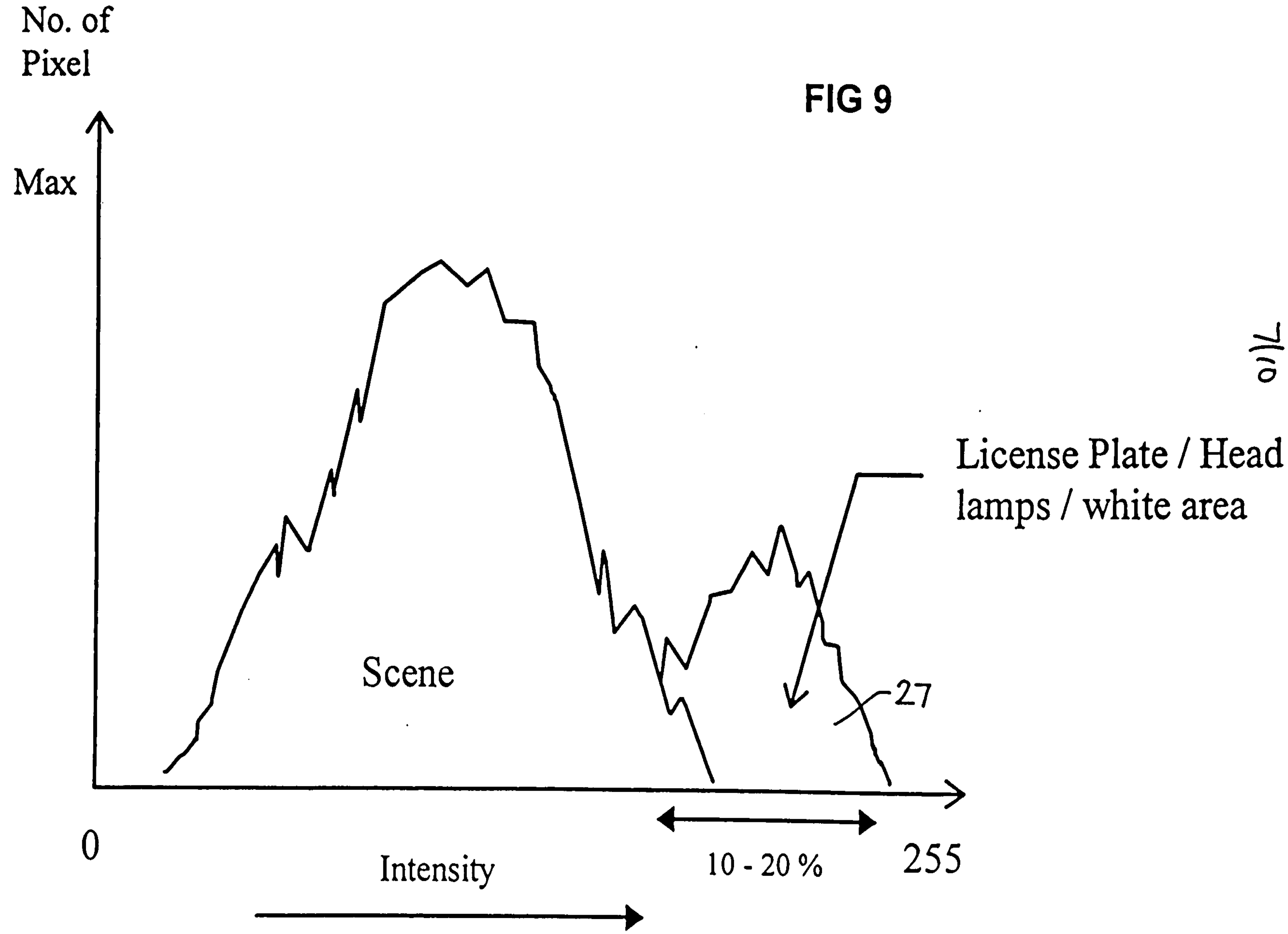


FIG 8

FIG 9


No. of
Pixel
Max
Scene
License Plate / Head
lamps / white area
27
0
Intensity
10 - 20 %
255

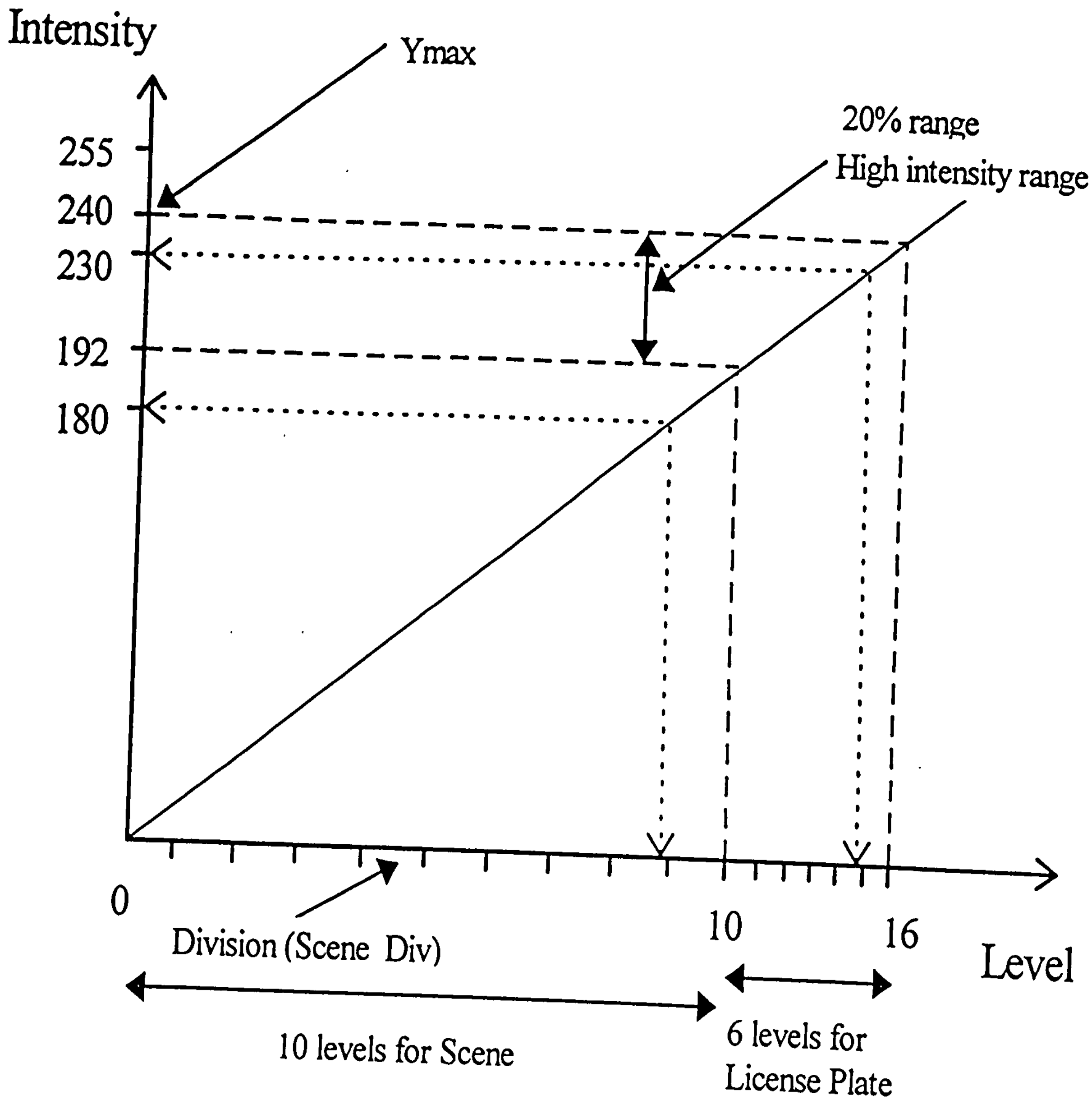

Intensity
Ymax
255
240
230
192
180
0
20% range
High intensity range
Division (Scene Div)
10
16
Level
10 levels for Scene
6 levels for
License Plate

FIG 10

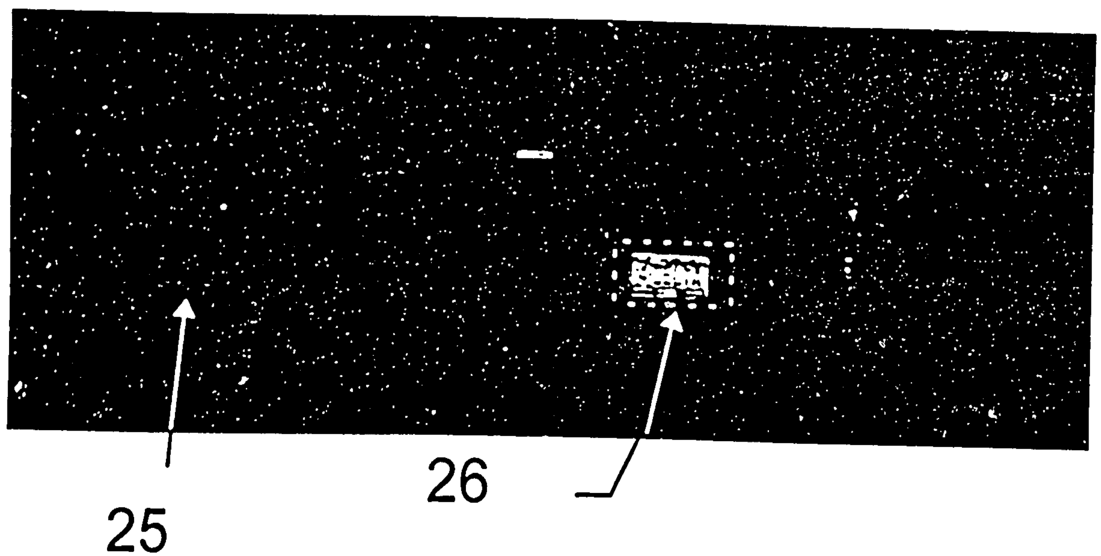


FIG 11b

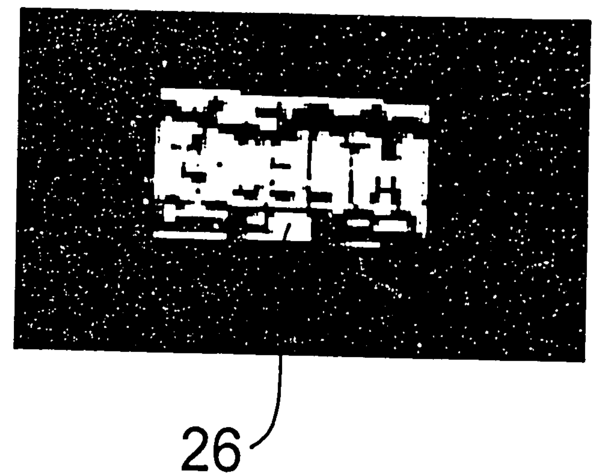
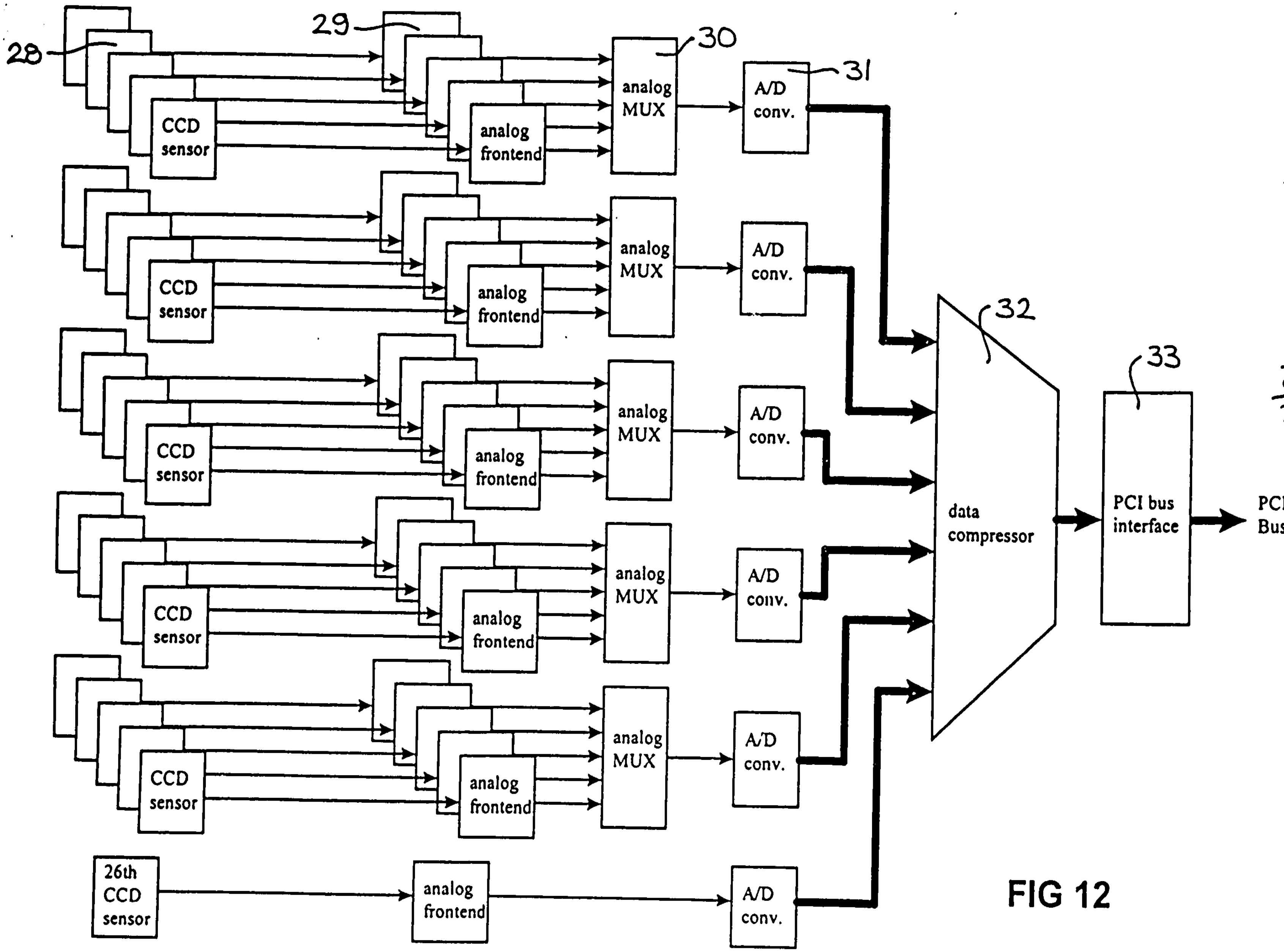


FIG 11a



28
29
30
31
32
33
CCD sensor
analog frontend
analog MUX
A/D conv.
26th CCD sensor
data compressor
PCI bus interface
PCI Bus

FIG 12